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Generic Diversity of Scleractinian Reef Corals in the Central Solomon Islands[1]

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Stehli and Wells (1971) have recently presented convincing evidence linking rates of reef coral evolution with the degree of reef coral generic diversity in different parts of the world. In the course of that investigation, the presently available data for the global distribution of hermatypic scleractinians were carefully evaluated. As a result, only 63 stations in the entire world ocean area were considered to be reasonably well sampled for hermatypic coral genera (Stehli and Wells 1971). When these stations are plotted on a map, a large gap in the Papua-New Guinea-Solomon Islands area becomes apparent. Few reef coral records have been reported for this region despite its proximity to the probable center of hermatypic scleractinian diversity in the Indo-Pacific. In the case of the Solomon Islands, the nearest localities considered "reasonably well sampled" by Stehli and Wells (1971) are Fiji, New Caledonia, Moreton Bay (Australia), and the Caroline Islands, each of which is well over a thousand km away.

The Solomons are also of interest because expeditions to the islands have repeatedly emphasized the remarkable paucity of coral reef development and the widespread mass mortality of shallow-water reef corals in their reports. In 1972, I had the opportunity to explore reefs at two sites in the central Solomon Islands (Munda, New Georgia; and Doma Cove, Guadalcanal). Large collections of reef corals were made at each site. The data reported here clearly show that a rich and highly diverse hermatypic coral fauna is present in the region despite the fact that environmental conditions at present are generally unfavorable for extensive development of coral reefs.

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GUADALCANAL

The north coast of Guadalcanal is nearly devoid of coral reef formations. The few fringing reefs that can be found are relatively narrow and poorly developed structures, largely emergent at low tide. The paucity of living coral is in striking contrast to comparable reef flats found elsewhere in the Pacific. Sand and gravel beaches are common, but not far from shore the coast plunges abruptly into the deep waters of Iron Bottom Sound. Little evidence of living coral reefs can be seen along most of the coastline, even from an aircraft. Yet shell collecting enthusiasts in Honiara claim to have found luxuriant reef coral communities at some locations. One of these sites was visited and explored with SCUBA.

The area reported on here is a reef slope off the promontory immediately southeast of Doma Cove (09° 19′ S, 159° 49′ E), about 25 km NW of Honiara. Only 400 m from the strand line the water is 60 m deep, but the average slope of the bottom out to a point 900 m from shore is between 11° and 12°. The promontory separates two arcuate bays lined with steeply inclined sand and gravel beaches. The fringing reef at the tip of the promontory is little more than meters to a few tens of meters wide and, except for small, widely scattered colonies of encrusting corals such as *Favites*, *Goniastrea*, and *Leptastrea*, it consists of eroded, barren reef-rock awash at low tide. The margin of this small coastal reef is highly serrated, with structures that in some respects resemble the spur and groove development of living reefs. A nearly vertical drop-off, 2 to 3 m high, sharply delineates the seaward margin of this dead reef.

Further offshore is a rubble-covered slope of variable width which persists as a distinct and easily recognizable zone to the point where water depth reaches 10 to 12 m. Although mostly floored with rubble-sized coral debris, the slope also has sand present. A conspicuous feature of this zone is the separation of the coarse-grained sedimentary material into discrete streamlike sand and gravel bands or stringers aligned more or less perpendicular to shore. Not a single living coral was found within this zone, whose topography is that of a smooth, even, gently inclined slope. A remarkable exception is the occurrence of large colonies of *Porites*, *Lobophyllia*, and other corals, some up to 3 m in diameter, but all totally dead *in situ*. These coral heads are highly conspicuous for several reasons: (1) their large size; (2) 100-percent mortality, although they are presently covered by up to 12 m of seawater of apparently normal salinity; (3) their emergence above the sea floor, which contrasts sharply with the more or less even surface of the rubble slope. These features suggest that prolific reef coral growth took place within this zone at some earlier time, followed by a catastrophic event which resulted in the widespread death of corals whose remains are now in the process of being buried by rubble; only the very large colony forms have not yet been covered. This hypothesis is further supported by the fact that much of the rubble consists of abraded sticks and rods of *Acropora* branches. There is no source for such rubble anywhere in the vicinity, except of course, from coral living below 15 m.

Reef coral growth begins around 10 to 12 m and is prolific between 15 and 30 m. Within this zone, the percentage of surface covered by living coral is estimated to average 20 percent, but there are numerous patches where the cover is virtually total. Bottom topography is highly irregular despite the overall high gradient of the reef slope on a large scale. Constant surveillance of one's position and movements is required to maintain proper orientation among the many steep hills and valleys. Reef knolls, 2 to 6 m across, frequently with near-vertical and even overhanging sides, rise abruptly to heights of 3 to 5 m, but none approaches the water surface. In places, "streams" of debris from the rubble zone penetrate into the zone of living coral, a reason why the average coral cover is relatively low when the general impression of coral growth is one of great luxuriance. Except for localized *Acropora* "forests" 6 to 10 m across, no one genus of reef coral seems to dominate the reef environment. Spectacular heads of *Porites* and *Lobophyllia*, however, draw attention because of their enormous size; the largest measured was close to 7 m in diameter. The coral fauna collected is listed in Table 1 and is described in a later section.

TABLE 1

SCLERACTINIAN CORAL GENERA AND SUBGENERA COLLECTED AT MUNDA AND GUADALCANAL, SOLOMON ISLANDS

SUBORDER ASTROCOENIINA	
Stylocoeniella (G)	*Seriatopora* (G, M)
Psammocora (M)	*Pocillopora* (G, M)
Stephanaria (M)	*Acropora* (G, M)
Plesioseris (M)	*Astreopora* (G, M)
Stylophora (G, M)	*Montipora* (G, M)
SUBORDER FUNGIINA	
Pavona (G, M)	*Polyastra* (G, M)
Pseudocolumnastraea (G, M)	*Leptoseris* (G)
Coeloseris (M)	*Pachyseris* (G, M)
Coscinarea (G, M)	*Fungia* (G, M)
Verrillofungia (G, M)	*Danafungia* (G, M)
Heliofungia (G, M)	*Parahalomitra* (G, M)
Halomitra (G, M)	*Herpolitha* (G, M)
Polyphyllia (M)	*Ctenactis* (G, M)
Pleuractis (G, M)	*Podabacia* (M)
Lithophyllon (G)	*Porites* (G, M)
Synaraea (G, M)	*Goniopora* (G, M)
Alveopora (G, M)	
SUBORDER FAVIINA	
Caulastrea (G)	*Plesiastrea* (G, M)
Favia (G, M)	*Favites* (G, M)
Oulophyllia (G)	*Merulina* (G, M)
Scapophyllia (G, M)	*Goniastrea* (G, M)
Platygyra (G, M)	*Leptoria* (G, M)
Hydnophora (G, M)	*Diploastrea* (G, M)
Leptastrea (G, M)	*Oulastrea* (G)
Cyphastrea (G, M)	*Echinopora* (G, M)
Galaxea (G, M)	*Acanthastrea* (G)
Lobophyllia (G, M)	*Symphyllia* (G, M)
Mycedium (G, M)	*Parascolymia* (G)
Oxypora (M)	*Pectinia* (G, M)
Echinophyllia (G, M)	*Physophyllia* (M)
SUBORDER CARYOPHYLLIINA	
Euphyllia (M)	*Physogyra* (G, M)
Plerogyra (G)	*Catalaphyllia* (G)
SUBORDER DENDROPHYLLIINA	
Turbinaria (G, M)	*Balanophyllia* (G)
Thecopsammia (G)	

NOTE: G, Guadalcanal; M, Munda.

Even though reef corals are the most conspicuous components of the reef community, many other organisms were observed and recorded, both in field notes and on film. Crinoids seemed particularly abundant, being often perched on small heads of *Porites* with arms extended. *Linckia* and other sea stars were found among the corals; and fresh feeding scars on *Stylophora* at 17 m indicate the presence also of *Acanthaster*. Alcyonarians were common, but molluscs appeared to be scarce, possibly because this site is frequently visited by shell collectors from Honiara.

Reef coral growth begins to disappear below 35 m at this location. Scattered clumps of the rather rare scleractinian *Catalaphyllia* were collected from this lower fore-reef zone, but beyond 35 m the slope is largely barren and mud-covered.

One of the striking characters of the reef slope examined at Guadalcanal is the ubiquitous presence of great quantities of mud (except, of course, in the rubble and littoral zones). The water tends to be murky despite a rather strong current flowing northeastward around the promontory where the reef is located. Clouds of fine, muddy sediment were created whenever coral heads were broken away from the substrate or in many places whenever a diving fin touched bottom—a considerable annoyance when photographs were being taken. Furthermore, large amounts of fine, dark brown mud were removed from interior cavities in coral heads when the specimens were later cleaned in the laboratory. Even the apices of conelike and rosettelike forms of *Turbinaria* were found to be filled in with fine-grained, largely noncalcareous sediment. Powerful currents flowing over the reef and around the promontory were experienced during each day of diving. This is usually the case according to those familiar with the area. It would seem that the preferential, relatively luxuriant growth of reef corals at this particular site is made possible by the high degree of water circulation.

CORAL REEFS AT MUNDA, NEW GEORGIA

Extensive coral reefs, at least in the structural sense, surround Munda Point on the large island of New Georgia. The area which I explored is centered at 08°22′ S, 157°14′ E (Fig. 1). Water temperature is high (over 29.3° C) in this region but tidal variations tend to be small (maximum range about 0.7 m). A barrierlike reef system 3 to 4 km from shore encloses the body of water known as Munda Harbor. The bottom topography of this lagoon is unusually irregular and is characterized by an intricate pattern of depressions or basins with intervening rises. Depths of 13 to 35 m are not uncommon between the sand-covered "hills" which are almost totally barren of living coral and which rise to within 2 or 3 m of the surface. Because of their small areal extent, these features are not shown on the map in Fig. 1. The many small rises and shoals extend over the entire area of the lagoon (Munda Harbor) but each is more or less equally spaced from its neighbors and is separated by water up to 35 m deep. Their remarkably uniform distribution, together with the characteristic branching and forking configurations exhibited by many of them, leaves little doubt as to their origin as older patch and pinnacle lagoon reefs which are presently submerged.

The barrierlike reef structure which more or less parallels the Munda coastline is between 400 and 800 m wide. The seaward margin is well defined by an exceptionally steep slope extending downward to depths of 900 m and more. Within 100 m of the reef edge at Black Rock, for example, the bottom is 66 m below sea level. The leeward limit of the barrier system is less well delineated, and in many places the reef top merges gradually with extensive sand flats which dip gently into the lagoon. These sand flats and the broad reef tops which break the surface at low tide are virtually barren of reef corals.

The meagerness of reef coral growth in shallow water in almost all reef environments examined is surprising to me on the basis of my experience in other parts of the Pacific. Only in Torres Strait have I seen such large areas obviously constructed by reef-building corals but presently almost totally devoid of them in shallow water, especially in the back-reef zones. Sediment in copious quantities is the only obvious factor inhibiting modern reef coral growth both in the lagoon and in the deeper water behind the barrier reef structures.

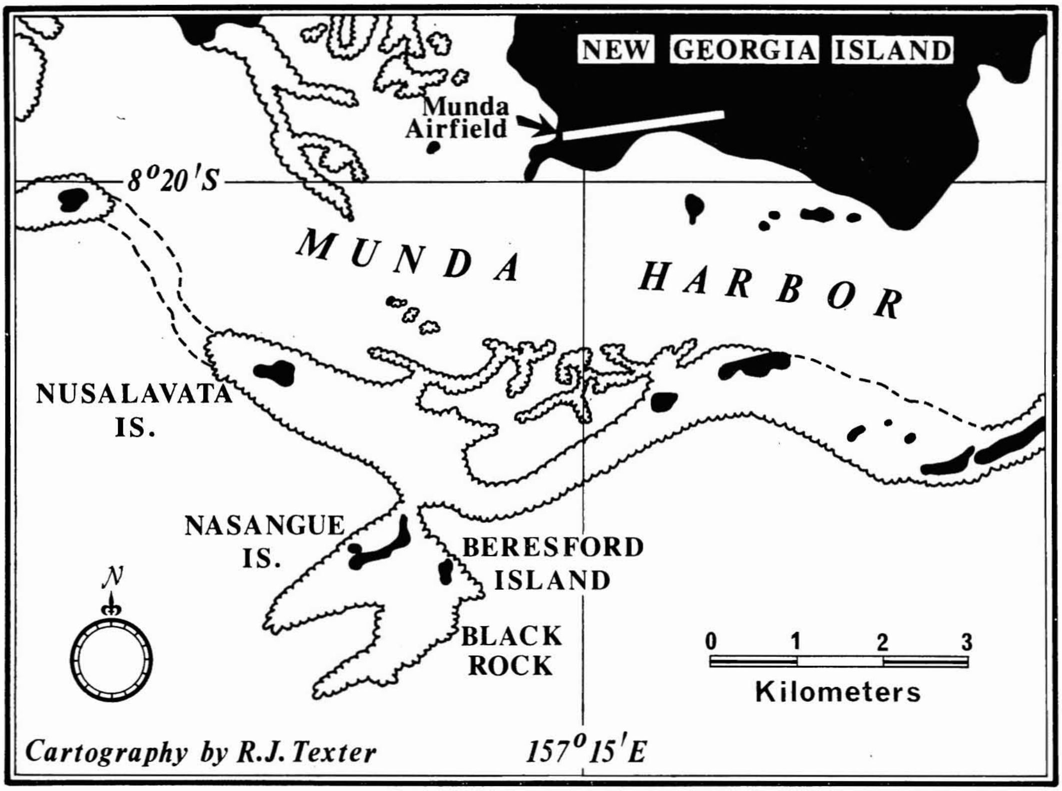

FIG. 1. Munda, New Georgia, area showing reefs where the scleractinian corals listed in Table 1 were collected. Dashed lines indicate zones where the reef margin is poorly defined.

Throughout the time this survey was made (August 1972) the water was everywhere turbid, and underwater visibility was low except in the open ocean on the fore-reef slopes of the barrier reef. A number of large coral colonies (particularly of *Porites*), now partially buried in mud and sand but totally dead even though they remain submerged during the lowest tides, suggests that conditions for coral growth within the lagoon were once more favorable than they are at present.

The prevailing atmosphere of death and decay, in terms of reef construction, is dispelled when the outer seaward fore-reef flanks are examined, for here is found a zone of luxuriant coral growth. For 2 days, good weather permitted exploration of these portions of the reef. Below the zone of breaking waves, the fore-reef slope drops off abruptly in most places, although occasional channels intersect the reef edge and lead to sand and rubble talus fans. Small vertical cliffs and overhanging ledges are also encountered; but spur and groove structure is not well developed, nor is much of an algal ridge present.

Prolific reef coral growth begins around 10 to 12 m and continues downward to depths close to 30 m, beyond which are sand-covered slopes and terraces with scattered clumps and patches of coral. Several large areas were encountered where dense thickets of *Acropora* completely obscure the substrate, but, in general, the living coral cover, excluding talus fans, was estimated to fall between 25 and 60 percent within the 10- to-25-m depth range. Reef fish appeared to be unusually numerous, and if 2 days experience is representative, this zone is well patrolled by rather large sharks.

The areas explored by the writer are: (1) about 5 km of coastline to the east of Munda

FIG. 2. Patch reefs, many of them vegetated, are numerous in the lagoon about 2 to 3 km NW of Munda airfield. As elsewhere in the Munda area, the paucity of living coral on the reef tops is conspicuous.

Point; (2) knolls and rises (Fig. 2) in the portion of Munda Harbor shown in Fig. 1; (3) about 4 km of sand flats and back-reef pools in the lee of the main barrier reef (this almost entirely by slow-moving canoe); (4) the top of the barrier reef (mostly on foot at low tide, Fig. 3); and (5) the seaward, fore-reef flanks of the main barrier reef shown in Fig. 1. The scleractinian corals collected are listed in Table 1, but virtually all of them were obtained from the fore-reef slope.

SOLOMON ISLANDS REEF CORAL FAUNA

The scleractinian coral genera and subgenera found at Munda and Guadalcanal are listed in Table 1, classified according to Vaughan and Wells (1943) and Wells (1956, 1964, 1966). Specimens of each genus and subgenus in that list were actually collected and returned to The Pennsylvania State University, primarily for study of the skeletal chemistry (Weber and Woodhead 1972). To the total of 66 scleractinians can be added the ahermatype *Tubastraea* which was not found by me but which was reported by Morton and Challis (1969: 481). This highly diverse reef coral fauna includes 10 astrocoeniids, 23 fungiids, and 26 faviids. Nonscleractinian carbonate-secreting corals which were found in abundance are *Tubipora*, *Millepora*, and *Heliopora*.

This collection differs from others which I have made in several respects. One of these is the conspicuous absence of the ahermatypic dendrophylliids *Tubastraea* and *Dendrophyllia*. Not a single specimen was taken either at Munda or at Guadalcanal despite a determined effort to find them. At both stations, the reef environments and depths examined were those in which these genera are usually found, but repeated searching of the underside of overhangs, of "caverns," and of vertical reef faces failed to yield even one of these corals.

Also unexpected was the failure to locate any trace of the oculinid *Acrhelia*, although

FIG. 3. Aerial view of a deep reentrant in the barrier reef system which encloses Munda Harbor. The broad reef tops are nearly devoid of living coral. View looking SW, with Beresford Island at left and Nasangue Island at right.

again it was specifically sought. This genus is abundant to the north (Rabaul), east (Fiji), and southeast (New Caledonia) where I collected it, but I found no specimens in the Solomon Islands. The third surprise was the extraordinarily large number of *Parascolymia vitiensis*, a solitary mussid which often grows to fairly large size (up to 12 to 15 cm across the calyx). *P. vitiensis* was found in abundance on all of the downslope reef transects at Guadalcanal, but only in a zone between 16 and 27 m deep.

Two rather rare reef corals are among those in the Guadalcanal collection, *Catalaphyllia plicata* and *Plerogyra sinuosa*. *Plerogyra* is abundant at depths between 20 and 27 meters. Each animal observed had its tentacles extended and these were photographed before the specimen was detached from the reef surface. *Catalaphyllia*, which was recognized as a new genus of reef coral only 1 year before the Guadalcanal specimens were discovered (Wells 1971), was seen only near the limit of hermatypic coral growth at Doma Cove, i.e. 30 to 35 m. The colonies were found as dusk was approaching on the last available day of diving, so illumination levels were too low to obtain photographs of this unusual meandroid euphylliid *in situ*. The only other localities where *Catalaphyllia* is known to occur are Amboina, New Caledonia, Palau, the Maldive and Pescadore islands, the Philippines, and Australia (Wells 1971). Other odd forms were also collected, for example, two new varieties of *Echinopora lamellosa*, one with smooth costae and the other with small calices (J. W. Wells, personal communication).

Further exploration of reefs in the Solomons, especially with SCUBA, will undoubtedly reveal the presence of a few more hermatypic scleractinians, and possibly even new species, but the records reported here are more than sufficient to dispel any doubts about the rich and highly diverse reef coral fauna of the region, a fauna which is present despite the notable lack of well-developed modern reef structures.

SUMMARY—CORAL REEF DEVELOPMENT IN THE SOLOMON ISLANDS

Despite warm water (mean annual temperature of surface water $\cong 29.3°$ C) and highly diverse reef coral communities in all adjacent regions, coral reef development is minimal in the Solomon Islands province. In the words of Morton and Challis (1969), "those experienced in coral ecology by common consent remark that the Solomon Islands reefs lack the luxuriance of those in many other parts of the Pacific...." Stoddart's (1969) survey led him to conclude that the poverty of modern coral growth is one of the most striking features of reef shores in the Solomon Islands region. Stoddart attributed this to the fact that most of the coastlines at present are zones of elevation, with steep and often vertical gradients which few corals are able to colonize.

More surprising than the overall paucity of reef formations, however, is the apparently widespread mass mortality of reef corals on existing reef structures from the intertidal reef flats to well into the sublittoral zone. Stoddart (1969) described dead reefs of this sort in some detail, and also noted from aerial photographs that reef flats are either devoid of living coral or if corals do occur they are often dead. As observed by Morton and Challis (1969), the condition of many of the relatively fragile and delicate corals (e.g., *Acropora*, *Montipora*) remains intact, suggesting that the death of these corals has been fairly recent. My exploration of numerous reef tops, both at Munda and on Guadalcanal, confirms the widespread death of shallow-water reef corals reported by Stoddart (1969) and by Morton and Challis (1969).

The answer to the "dead reef problem" of the Solomons is not yet conclusively known. Morton and Challis (1969) discounted the possibility of a widespread coelenterate pathogen in favor of a tidal explanation, although they conceded that exceptionally heavy rainfall might have contributed to the mortality of shallow-water reef corals. Available tidal data, however, indicate a maximum range of only 0.7 m for Guadalcanal.

A more plausible explanation has been proposed by Stoddart (1969) who emphasizes the importance of recent tectonic activity throughout the Solomon Islands region. Evidence for coastline instability, some relatively recent, is overwhelming. Sea level changes of noneustatic origin have occurred in both the up and down directions relative to the present sea level datum, as indicated by raised fossil reefs, elevated tidal notches and reef platforms, etc. on the one hand, and drowned terraces, submergent reef structures, etc. on the other. The subtidal coasts are characterized by near-vertical cliffs of old coral limestone (Stoddart 1969).

The morphology of the coral reef which I examined on the north coast of Guadalcanal is consistent with the intermittent raising and lowering of coastlines as proposed by Stoddart (1969). Here a once flourishing, albeit small, coral reef appears to have been elevated sufficiently to kill all corals in the zone between shore and the present 10 to 12 m depth contour. Resubmergence followed sometime later. During the intervening period, most of the branching forms such as *Acropora* were fragmented, forming rubble debris which now covers all but the very largest *Porites* and *Lobophyllia* colonies that grew in this zone.

An alternative explanation, however, cannot be ruled out with the evidence presently available. Mass mortality of reef corals in the 0 to 12 m depth zone might have resulted from the passage of intense tropical storms through this area of the Solomons. Such storms are capable of causing severe reef damage, at least locally, as did Hurricane Hattie off the coast of British Honduras in 1961 (Stoddart 1963).

Along the north and northeast coasts of Guadalcanal, at least, the abundance of sediment provided by streams flowing into Iron Bottom Sound must also exert a strong influence on coral reef development. Thriving reef coral communities can be expected only in the vicinity of headland promontories where hard-rock substrate is available and where strong longshore currents restrict sedimentation rates to rather low levels.

The paucity of reef development and the widespread mortality of corals in shallow-water environments should not, however, be misconstrued to indicate either the absence of a thriving reef coral fauna or an attenuation of reef coral diversity. The coral collections reported on here demonstrate that virtually all

Indo-Pacific hermatypic scleractinians are present in the area, and that the Solomon Islands region ranks near the top in terms of worldwide reef coral generic diversity. The animals are obviously here; only a favorable combination of geomorphological conditions is needed for renewal of reef building on a scale as large as in the past.

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